National Aeronautics and Space Administration

Human Research Program

Space Radiation Program Element

Requirements and Gaps

Develop and Validate Standards

- By performing research to inform the development and validation of Space Radiation Permissible Exposure Limits for
  - Radiation Carcinogenesis
  - Acute or Late Central Nervous System Effects
  - Degenerative Tissue Effects
  - Acute Radiation Syndromes

Quantify Space Radiation Human Health Risks

- By developing validated mechanisms, models and methods to quantify the risk of Radiation Carcinogenesis and Acute Radiation Syndromes for Exploration Missions
- By performing the research necessary to develop an evidence base for radiation induced Acute or Late Central Nervous System Effects and Degenerative Tissue Effects
- By identifying whether synergistic effects from other spaceflight factors modify radiation health risks

Mitigate Risks thru Countermeasures & Technologies

- By developing tools and methodologies to evaluate shielding approaches and vehicle requirements for mission planning and design
- By performing the research necessary to develop and validate biomedical or dietary countermeasures for radiation carcinogenesis and other risks quantified as significantly high

Treat and Monitor Unmitigated Risks

- By developing tools to assess and monitor compliance with the Space Radiation Permissible Exposure Limits
- By developing biodosimeter and biomarker technologies for radiation carcinogenesis and other risks quantified as significantly high
- By developing in-flight physical detector technologies through TRL 4 to monitor compliance with the Space Radiation Permissible Exposure Limits
- By supporting the transition of research deliverables to technology maturation and operational programs

Schedule Overview

Agency Mission	2006–2013	2014–2019	2020–2026	Contributions to National Priorities
Lunar Sortie Missions by 2019	Perform research on dose-rate effects of protons, develop shielding design tools; apply probabilistic risk assessment to lunar missions	Validate radiation environment and transport models using lunar data; Validate models of proton dose -rate effects	Develop and deploy operational strategies for managing SPE risks; Apply biomarker methods to samples from lunar crews	Contribute to increased understanding of solar physics; Apply biomarker technologies to problems on Earth
Lunar outpost Missions up to 240 days	Use NSRL to simulate space radiation to understand their biological effects; Compete radiation transport codes and design tools	Continue NSRL research on risks; perform research on biological countermeasures; optimize shielding designs for Mars missions	Finish NSRL research on countermeasures; Develop diagnostics of radio -sensitivity and gene therapy for prevention and/or treatment of radiation damage	Design exploration missions; Apply new knowledge of radiation effects and NASA computational biology models to human diseases on Earth
Mars Exploration Missions by 2030	New risk model that reduces uncertainties in projections to less than 2 -fold; Determine if CNS and degenerative risks from GCR will occur	Revised risk model with uncertainties in risk projections to less than 50%; lunar -instruments to measure Mars surface environment at solar minimum	Apply knowledge on individual risk assessments and biomarkers; integrate accurate long -term solar weather predictions for Mars assessments	Apply countermeasure knowledge to diagnosis, prevention and treatment of diseases on Earth